Space Weather Technical Forecast

Issued on Sunday, 19 February 2023 at 12:37 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: M-flares (R1/R2) likely with an ongoing X-flare potential (R3). CME arrivals possible day 1 and 2 (19th and 20th), with G1/Minor Storms likely.

Analysis of Space Weather Activity over past 24 hours
Solar Activity: Low with only C-class flares observed. The most notable sunspot region is AR3229 Dkc/Beta-Gamma-Delta which was still recovering from its X2.3 flare on the 17th, with post-flare arcade loops declining though the day. The group has an East-West aligned polarity separation line, and has now developed a delta spot within the leading penumbral area, which suggests this has the potential for further flaring. There are a total of seven sunspot regions on the visible solar disc, with AR3226 Eko/Beta-Gamma in the northwest showing some simplification, and it remained inactive. AR3225 Dai/Beta in the southwest also exhibited some minor growth. The other regions are generally mature and stable. A very slow CME seen in the southwest is currently being assessed for an Earth directed component, but it currently seems unlikely.

Solar Wind / Geomagnetic Activity: Solar winds as measured by DSCOVR at L1 showed a decline to ambient levels, as the recent High Speed Stream (HSS) eased. Wind speeds declined from slightly elevated levels around 440 km/s to ambient levels near 360 km/s, with density near or below average. The total IMF strength, Bt, was Weak below 6nT. The north-south component, Bz, varied weakly between +/-5nT. Phi angle was largely positive (away from the Sun). Geomagnetic activity was Quiet to Unsettled (Kp 0-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES-16 remained at background levels. High energy electron flux (greater than 2MeV) at GOES16 was at largely background levels. The associated 24 hour electron fluence has been well below the Active (1e8 integrated pfu) threshold, reaching 4.64e6 integrated pfu at 19/0000 UTC.

Four-Day Space Weather Forecast Summary
Solar Activity: Low to Moderate activity expected, with isolated M-flares likely, but also a chance of rising again to High with further X-flares. The main risk for further significant flaring is AR3229 in the northeast.

Solar Wind / Geomagnetic Activity: CMEs from the 15th and 16th have now likely missed Earth. A further fast CME associated with the X2.3 flare on the 17th has been assessed to have an Earth-directed shock component, albeit with most of the material missing to the east and behind Earth. This is anticipated to arrive on day 2 (20th), however there is sufficient uncertainty that an earlier arrival on day 1 (19th) cannot be ruled out. The impact of any arrival is low confidence. Further coronal hole fast wind influence is possible on days 3 or 4 (21st and 22nd). Generally Quiet activity is expected with Unsettled intervals. However, the CME arrival will likely bring a period of Active to G1/Minor Storm, perhaps reaching G2/Moderate storm. Unsettled to Active conditions also likely later day 3 or day 4 from any fast wind arrival.

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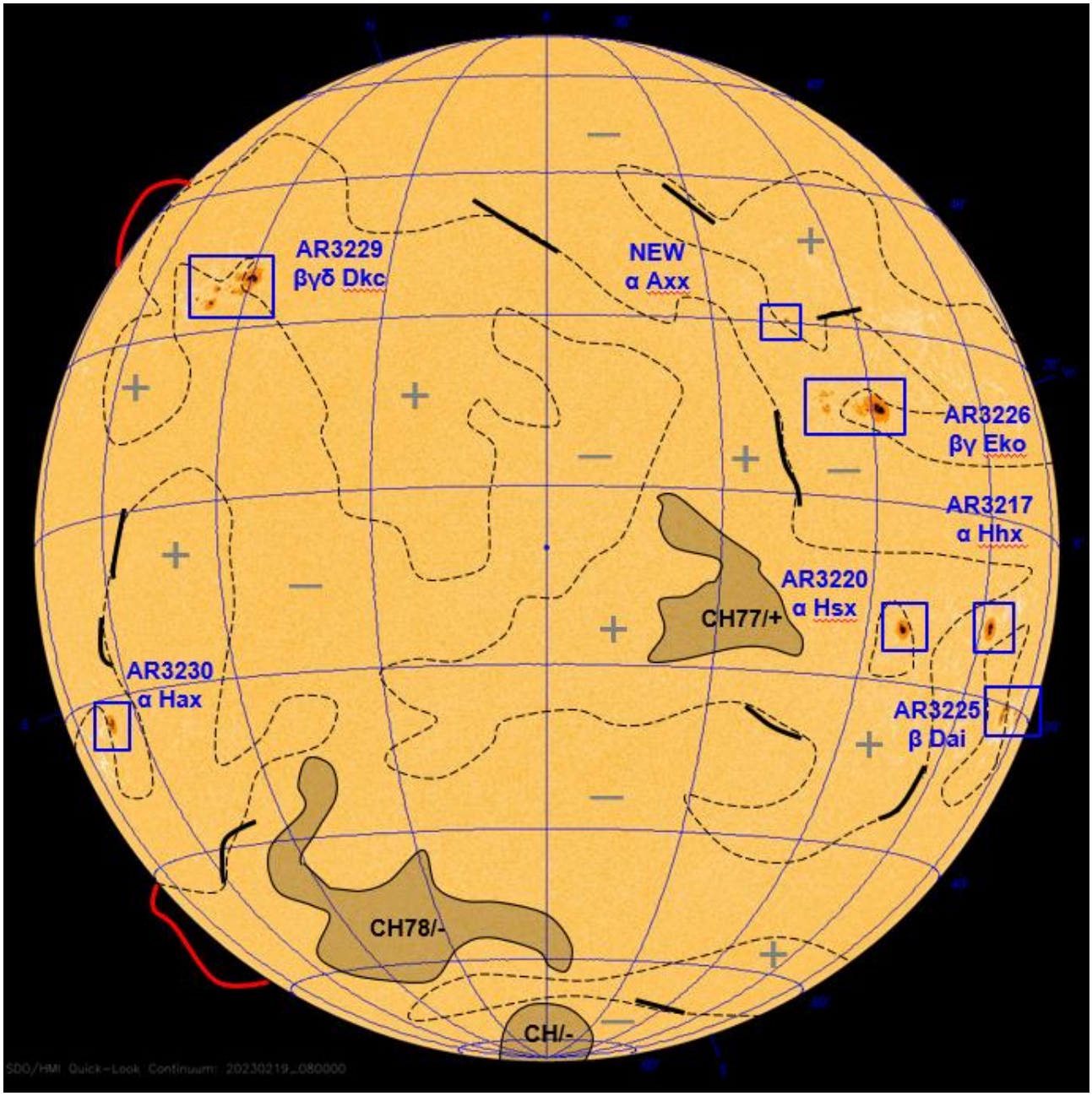
Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is most likely to remain at background levels, but with a slight chance of rising towards the S1 level, perhaps exceeding it if any larger flares occur. High energy (greater than 2 MeV) electron flux may increase later in the forecast period, but with low confidence due to potential CME arrivals. The associated 24 hour fluence is expected to remain below the Active threshold (1e8 integrated pfu).

Figure 1. Solar Analysis Valid 19/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The geomagnetic forecast is Low confidence at this stage.

A CME from a filament eruption just east of the central solar disc was originally forecast to arrive late 17th, but has yet to be observed. It is now considered most likely that this has missed Earth. More notably, a fast CME was observed on 17th with the X2 flare from AR3229. The majority of the ejecta is directed away from Earth, towards the east, however a clear halo shock was visible in coronagraph imagery. Analysis of such shocks and their expected impact carry additional uncertainty. However, this is currently expected to arrive during day 2 (20th), although some faster analyses do give an arrival as early as late day 1 (19th).

A further enhancement is also likely on day 3 or 4 (21st or 22nd) from the arrival of the fast wind of CH77. This is a persistent feature, although appears a little more ragged on imagery on this occasion. Furthermore, any enhancement is likely to be fairly muted due to its positive polarity being disfavoured for connection close to the March Equinox.

Geomagnetic activity is forecast to be generally Quiet with Unsettled intervals. However, the CME arrival late day 1 or day 2 will likely bring a period of Active to G1/Minor Storm, perhaps reaching G2/Moderate storm. Unsettled to Active conditions also likely later day 3 or day 4 from any CH fast wind arrival.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	30	60	20	10
Strong	G3	No	5	5	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
18/0145	Full	AR3229	NE quadrant	700 km/s	20/0900 UTC	Significant uncertainty in arrival time. Mostly shock expected

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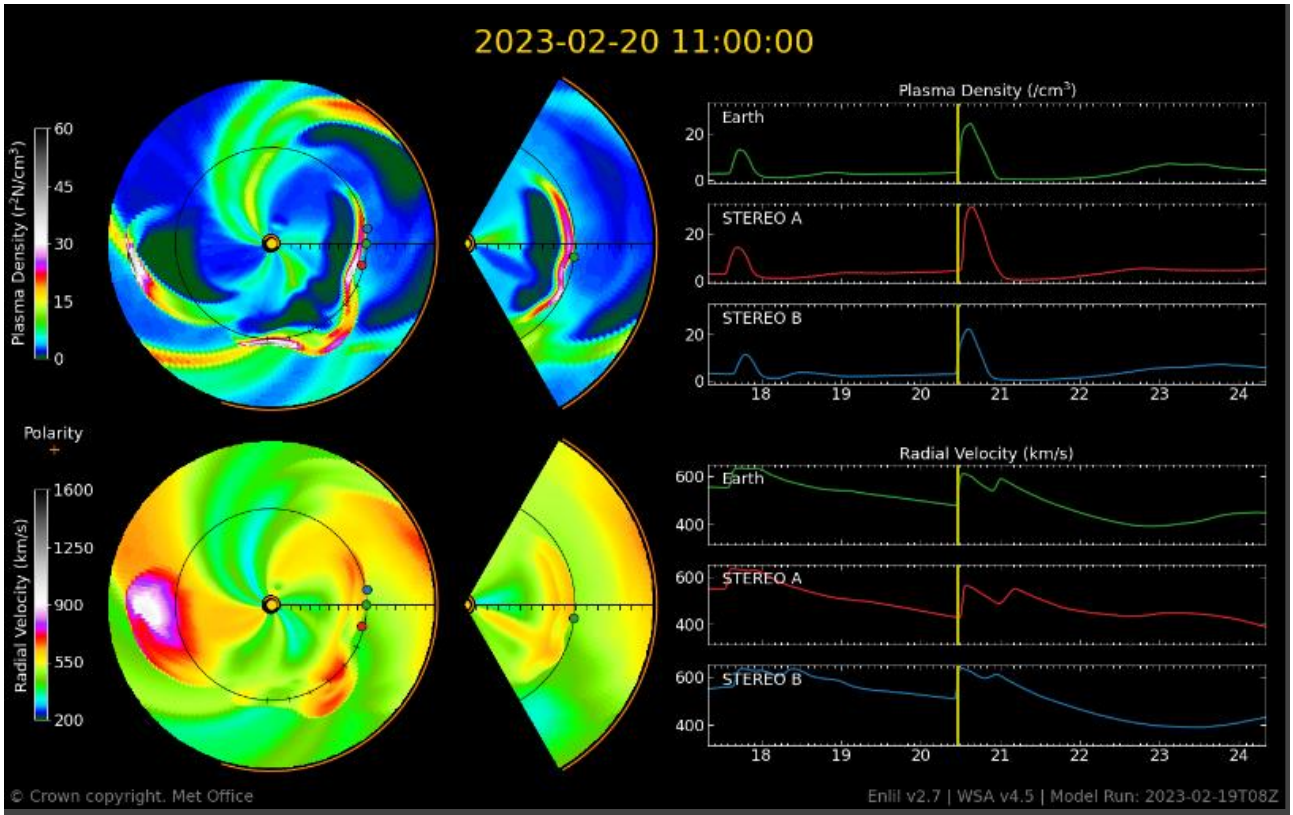
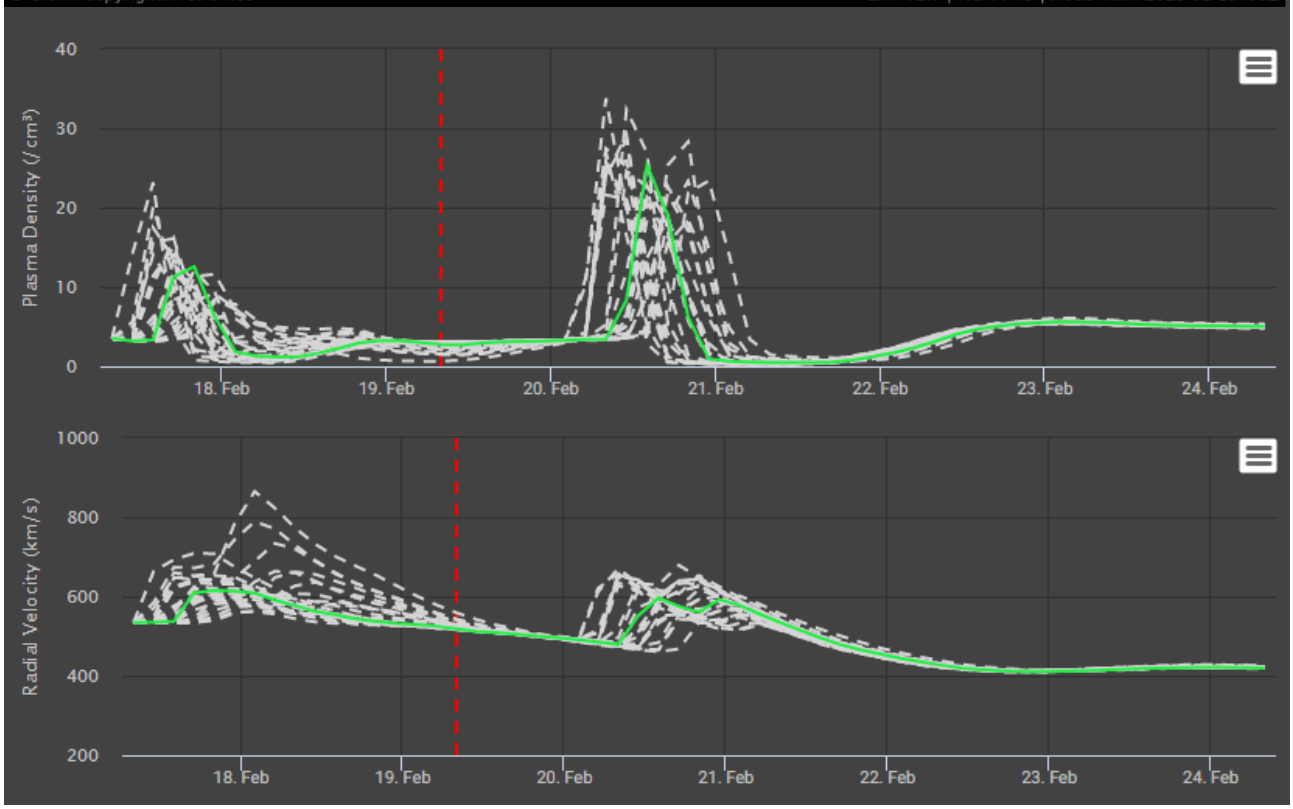
Figure 2: MOSWOC Enlil and ensemble, showing the CME arrival around the middle of the 20th. However, significant uncertainty in speed and therefore arrival time, which could be earlier into the 19th.





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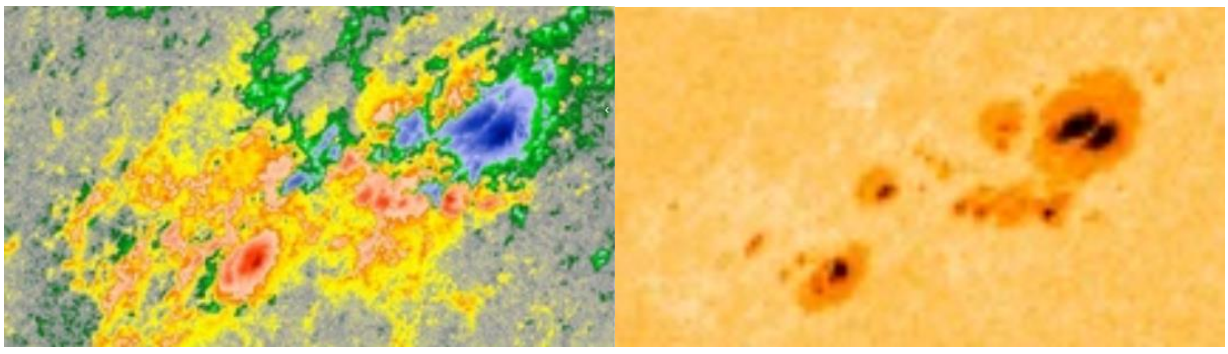
Radio Blackouts - X-Ray Flares:
Further Moderate Activity is likely, with a chance of this rising to be Strong, with any further X-flare activity.

There are seven sunspot regions on the Earth-facing disc. AR3229 Dkc/Beta-Gamma-Delta in the northeast was the source of a strong X2.3 flare on the 17th, despite having a relatively simple appearance on SDO Intensitygram and Magnetogram imagery. However this belied a more complex and twisted magnetic field above the region that was visible in various SDO aia products. Post-flare, the region has remained relatively small, but still has some distinct looping visible on, for example, SDO aia-171. However, it has recently developed a delta spot in the leading penumbral area, suggesting an ongoing flare risk from this region.

AR3226 Eko/Beta-Gamma in the northwest has remained largely stable, with the opposite polarity spots giving the Beta-Gamma configuration starting to fade. The other regions are generally small, and simpler, although AR3225 Dai/Beta in the southwest has seen the growth of some intermediate spots.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	60	50	40	40
Very Active	R3 to R5 X Class	No	25	20	15	15

Figure 3: AR3229 intensitygram and magnetogram showing a small delta spot in the leading penumbral area, suggesting the potential for further flares.



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Solar Radiation Storms - (High Energy Protons):
High energy (greater than 10MeV) proton flux, as observed by GOES16, is currently at background levels. A proton response was not observed from the X2.3 flare on the 17th, however there remains a chance of further strong flares from this region. There are also a couple of spots in the western hemisphere that have the potential for M-flaring, which is a more favoured location for Earth-directed proton events. This gives an ongoing slight chance of proton count rates increasing towards, or breaching the S1 Minor Radiation Storm threshold.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	10	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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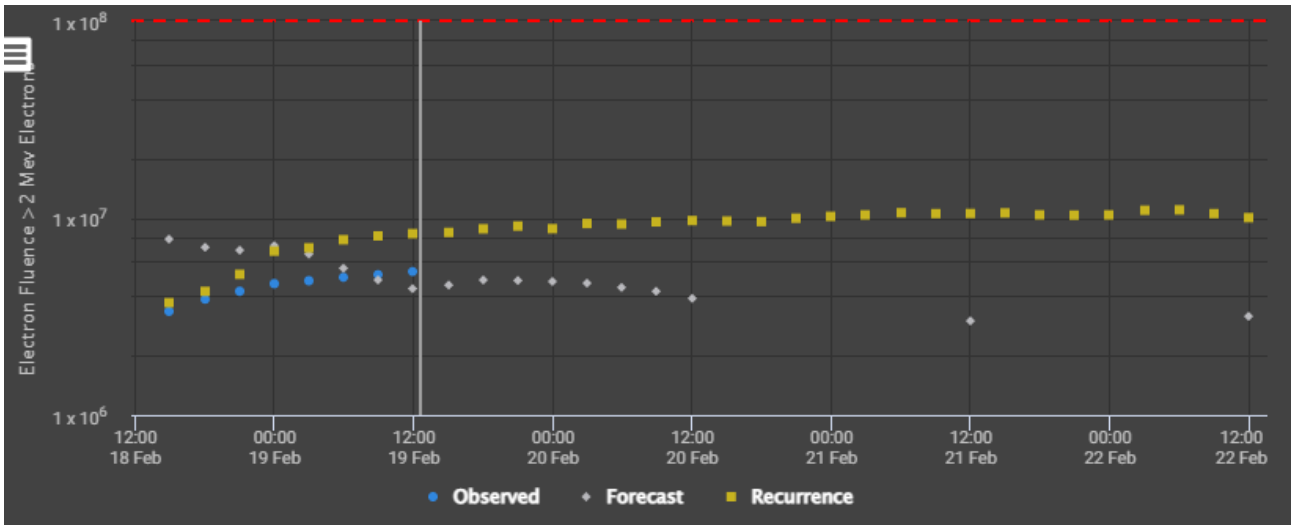
High Energy Electrons Event (≥ 2MeV):
High energy electron flux (greater than 2MeV) observed at GOES-16 is currently at Background levels. Any more persistent increase in flux is likely to be suppressed by a CME arrivals either later day 1 or on day 2 (19th and 20th), although some recovery towards Moderate levels is then possible day 3 or day 4 (21st or 22nd). There is a slight chance this may approach high, however this is then likely to be suppressed further by any solar wind enhancement that occurs from the arrival of the high speed stream of CH77.

The associated 24 hour fluence is expected to remain below the Active threshold, with only a slight chance of rising above later in the period. REFM maintains below Active fluence, and this is likely to be a reasonable guide through the period.

GEO Electron Environment Probability (Exceedance)	Level ($cm^{-2}\ sr^{-1}\ day^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	5	5
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 4: MOSWOC REFM showing a below Active trend, which seems reasonable.



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